AD A050889

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ARI TECHNICAL REPORT
TR-77-A13

DEVELOPMENT AND APPLICATION OF DECISION AIDS FOR TACTICAL CONTROL OF BATTLEFIELD OPERATIONS: DECISION SUPPORT IN A SIMULATED TACTICAL OPERATIONS SYSTEM (SIMTOS)

by

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DECEMBER 1977

Contract DAHC 19-75-C-0008

Prepared for

U.S. ARMY RESEARCH INSTITUTE
for the BEHAVIORAL and SOCIAL SCIENCES
5001 Eisenhower Avenue
Alexandria, Virginia 22333

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18 ARI

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: Technical Report 77-A13 — 19 TR-77-A13

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): 6 DEVELOPMENT AND APPLICATION OF DECISION AIDS FOR TACTICAL CONTROL OF BATTLEFIELD OPERATIONS: DECISION SUPPORT IN A SIMULATED TACTICAL OPERATIONS SYSTEM (SIMTOS).

5. TYPE OF REPORT & PERIOD COVERED: 9 Final rept. Aug 74 - Nov 75, Final 8/74 - 11/75

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): 10 Robert A. Levit, Berton J. Heaton [redacted] David G. Alden

8. CONTRACT OR GRANT NUMBER(s): 15 DAHC 19-75-C-0008

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Honeywell Systems and Research Center, 2600 Ridgeway Parkway, Minneapolis, Minnesota 55413

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 16 2Q762717A765

11. CONTROLLING OFFICE NAME AND ADDRESS: Army Research Institute for the Behavioral and Social Sciences PERI-OS, 5001 Eisenhower Avenue, Alexandria, VA 22333

12. REPORT DATE: 11 Dec[redacted]77

13. NUMBER OF PAGES: 67 12 78p.

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Previous work on this project is reported in ARI Technical Reports TR-77-A2 and TR-77-A3; work was monitored technically by personnel of the Battlefield Information Systems Technical Area of ARI. Three technical appendixes to this report are on file at ARI Headquarters.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Command and control	Tactical Operations System (TOS)
Decision making	Information processing
Decision support	Simulation
Decision aids	Simulated Tactical Operations System (SIMTOS)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In an experiment designed to evaluate the effectivenss of an automated decision support system on tactical information processing and decisionmaking performance, 25 experienced Army officers played the role of Division G3 in the Simulated Tactical Operations System (SIMTOS). Results of the evaluation demonstrated that the concept of decision support is sound, although specific measures of tactical performance were insensitive to player actions. The decision support complex increased players' ability to interact effectively with SIMTOS and increased their satisfaction with the system. Further development

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402 349

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20.

of automated decision support for tactical decision making is warranted.

Development and Application of Decision Aids for Tactical Control of Battlefield Operations: Decision Support in a Simulated Tactical Operations System (SIMTOS)

BRIEF

Requirement

To examine the nature of human/computer interactive decision making in an automated tactical environment.

Procedure

A decision support complex consisting of adaptive estimates of the situation and resource allocation decision aids was developed and integrated into the Army Research Institute's Simulated Tactical Operations System (SIMTOS). An experiment was conducted to compare the effects of the various types of decision support on tactical information processing and decision making performance.

Findings

The results of the evaluation demonstrated that the concept of decision support is a sound methodological alternative for decision aiding in automated tactical environments. Although conclusions were not definitive due to the insensitivity of system tactical performance measures, the efficacy of an interactive data base with decision support mechanisms was shown.

Utilization of Findings

From the decision aiding investigations in SIMTOS, a rich data base on human/computer interaction with the system has been generated. A set of requirements for G-3 interaction in a simulated tactical operations system could be developed by combining knowledge gained through analysis of SIMTOS data with knowledge of G-3 tactical doctrine. Such a set of requirements would stipulate the human/computer dialog and data base structure necessary for G-3 operations in automated environments.

This volume concludes a series of reports done by Honeywell for Army Research Institute for the Behavioral and Social Sciences (ARI). The original three-volume series comprised the final technical report under Contract DAHC 19-73-C-0069: "The Development and Application of a Decision Aid for Tactical Control of Battlefield Operations," by Robert A. Levit, David G. Alden, Jean M. Erickson, and Berton J. Heaton, August 1974. Volume 1, "A Conceptual Structure for Decision Support in Tactical Operations Systems," has since been published as ARI Technical Report TR-77-A2 and placed in the Defense Documentation Center (DDC) for public retrieval under accession number AD A040 606. Volume 2, "Decision Style Measurement and Decision Support Software Specifications," is a computer printout available in the ARI files. Volume 3, "A Preliminary Evaluation of a Decision Support Complex in SIMTOS," has been published as ARI Technical Report TR-77-A3 and placed in DDC with accession number AD A040 563. The three-volume set is referenced in the present report as a Honeywell Technical Report by Levit et al., 1974.

The present report was done by Honeywell under Contract DAHC 19-75-C-0008. Three appendixes submitted and cited as part of the report are available in the files of the Battlefield Information System Technical Area of ARI, Alexandria, Virginia. The appendixes are:

Appendix 1. Handbook for Research in a SIMTOS

Appendix 2. Decision Aiding Software Specifications

Appendix 3. Data Recording Procedures and Derivation of Dependent Measures.

The entire project is part of a continuing ARI program on simulated tactical operations systems (SIMTOS).

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INTRODUCTION

BACKGROUND AND REQUIREMENT

The amount and complexity of information available for decision making in tactical environments is rapidly increasing. Sophisticated new sensors combined with the increasing mobility and short reaction times associated with tactical operations have significantly influenced the cognitive workload of the Army field officer. The process of tactical decision making has been particularly affected.

Basically, the tactician is confronted with two types of decision making situations. In one situation, the tactical environment is such that a clear application of military doctrine is appropriate. In these "programmed" situations, decision making consists primarily of a process of evaluating a current situation relative to a similar situation for which tactical doctrine exists. Once this decision is made, recommended courses of action are available. In a second decision situation, the tactician finds that tactical doctrine does not provide clear guidance for his decision making activities. His task becomes finding an innovative approach to his situation and making decisions appropriate to a novel environment. This type of decision making can be called "unprogrammed."

Crucial to making decisions in both these contexts is the concept of tactical information management. To make programmed decisions, the tactician must evaluate information to assess the similarity of his position with those for which recommended courses of action are available. In an unprogrammed decision making environment, the tactician requires information to serve as the raw material from which his planning will evolve.

To supplement the tactician's information management resources (his staff), the Army is presently developing new concepts for tactical data processing. Systems such as TACFIRE are designed to take some of the programmed decision making workload. Systems such as an automated Tactical Operations System (TOS) are conceived of as aids for helping Army Command staff manage and integrate information in both programmed and unprogrammed situations. The development of such systems however, requires the establishment of guidelines for how Army staff can and will use such resources.

The present research continues the Army Research Institute's (ARI) efforts to meet the Army's requirement for knowledge concerning the nature of tactical decision making and how automated systems can be developed to be responsive to the Army decision making environment. The emphasis of this investigation is to assess the effectiveness of various automated decision aiding techniques on tactical performance and user satisfaction. Pivotal to this investigation is ARI's Simulated Tactical Operations System (SIMTOS). SIMTOS is a research tool which serves as a test bed for the study of tactical information requirements and decision making.

THE NATURE OF AUTOMATED DECISION AIDING

The complexity of modern military operations dictates that computers be used to supplement the information gathering and processing capabilities of command personnel. As such, the computer itself constitutes a potentially powerful aid to the tactical decision maker. The computer provides a tool through which large data bases can be marshalled and displayed. The tactician however, must be able to use the power of the computer to his best advantage. His tactical information system must be sensitive to his information needs and be able to provide this information in a concise and timely manner. The purpose of developing decision aiding techniques for automated tactical systems is to insure that these systems are responsive to tactical needs. In many ways, decision aiding methodology can supply the crucial interface between the decision maker and his automated tactical system.

Decision aiding techniques can fulfill this function at many levels of the decision making process (e.g., problem sensing, information gathering, alternative generation and weighting, action selection). The level at which decision aiding techniques function is determined by the command environment, the information processing characteristics of the tactician, and the nature of the tactical information system in use. Past research on decision aiding techniques indicates that they should meet certain criteria if they are to be effective[1]. Decision aiding techniques should:

- Give the user greater control of his command environment.

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[1] Levit, R., Alden, D., Erickson, J., and Heaton, B., Development and application of a decision aid for tactical control of battlefield operations. Honeywell Technical Report, 1974.

- Be acceptable to the user. That is, the user must perceive use of the aid as the most efficient method of reliable and effective performance.

- Improve the accuracy and effectiveness of user information processing and tactical performance.

- Encourage the translation of data into tactical decisions.

These are mandatory characteristics for a decision aiding technique. In addition, these techniques should:

- Enable the decision maker to interpret each action as part of the total tactical situation.

- Aid the tactician in performing duties directly relevant to his task.

- Facilitate selective information retrieval.

- Provide feedback on the results of actions.

- Facilitate the generation of new tactical relationships.

- Respond to individual differences in information processing.

Since decision aids function as an interface between the tactician and his automated system, aiding techniques should be designed in accordance with the principles of meaningful human/computer dialog. Meaningful human/computer dialog may be defined as a two-way communication that is mission oriented where both parties contribute a necessary function, each performing a role that complements the other. The principles of meaningful human/computer dialog include the following:

- Dialog should be interactive, with mixed initiative communication the rule rather than the exception.

- Dialog should be easy to use, designed for the operator with a minimum of computer experience.

- Dialog should be responsive to the fact that different individuals analyze and react differently to the same objective situation.

- Dialog should operate in parallel with and reflect the pacing of the real time characteristics of the mission.

Several investigators (Levit et al., 1974; and Albright, 1975) have indicated that it is unlikely that one decision aiding technique can fulfill all these requirements. A new concept of decision aiding in automated command and control is necessary. This concept is that of a decision support system.

THE CONCEPT OF DECISION SUPPORT IN SIMTOS

As part of a previous study of decision aiding in ARI's SIMTOS, the concept of a decision support system was developed (Levit et al., 1974). The concept of decision support recognizes that a single decision aiding technique is inadequate for realizing the best capabilities of the human/ computer dyad. A number of decision aiding techniques of mixed methodologies directed at different levels of the decision making process and system operation are required. Such a complex of decision aids can be called a decision support system.

During 1974, a decision support system was designed for the SIMTOS. A situational methodology was used to develop this system. This method emphasizes analysis of decision making and decision aiding in specific

contexts, such as tactical scenarios.[2] Since the SIMTOS defensive scenario was to serve as the environment for decision support, the system was designed to complement the existing scenario software and the established activities of a division G-3. (One segment of the SIMTOS defensive scenario, which is based on a Command General Staff College problem, requires that the SIMTOS user act as a division G-3.) The proposed SIMTOS decision support complex was to consist of:

- Estimate of the situation aiding. This technique provides the decision maker with a core of relevant information for planning a defense.

- Resource allocation aiding. This technique provides the decision maker with the information and communicative authority for dispersing certain resources in a systematic manner.

- Contingency plan aiding. This technique provides the decision maker with the ability to play a "what if" game and thereby assess the consequences of alternative actions on combat parameters.[3]

Furthermore, the SIMTOS decision support system was to be a mixture of adaptive and normative aids (Levit et al., 1974). Adaptive aids would be responsive to the SIMTOS user's decision style, that is, his characteristic way of processing information. This type of aid would be directed toward

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[2] The situational approach to developing decision support system is documented in Levit et al., Volume 1, 1974.

[3] Due to time limitations on software development a contingency planning aid was not implemented. Specifications for such an aid however, are presented in Appendix 2 of this report.

the decision maker's information acquisition and interpretation activities. Normative aids would be designed to "fit" a general user. They would be oriented toward the action selection segment of decision making.

The SIMTOS Decision Support System

As implemented for the present experiment, the SIMTOS decision support system consisted of estimate of the situation aids for both the planning and combat segments and a resource allocation aid for the combat segment. For planning, three forms of an adaptive estimate aid were designed, each responsive to a dimension of decision style.[4] One estimate aid, in both a normative and adaptive form, was designed for the combat segment. A normative resource allocation aid was also developed for the combat segment. In addition, some details of the SIMTOS human/computer dialog were changed to accommodate the introduction of the decision support system. The remaining portion of this section clarifies the nature of the SIMTOS decision support system.

Before the introduction of decision support in SIMTOS, the preparation of the G-3 Operation Plans was a paper and pencil task and the products of the task were not used during the combat segment of the exercise. The decision support techniques implemented for the planning segment of this experiment replaced the paper and pencil task with an on-line planning procedure. The planning exercise consisted of a series of tactical "steps," each designed around a crucial aspect of G-3 planning. These "steps" (a total

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[4]These dimensions as well as the concept of decision style are fully discussed in Levit, et al., Volume 1, 1974.

of six) could be displayed on an auxiliary CRT for on-line completion. Rather than develop their own solutions, the G-3 players chose an alternative from a set of available answers for each step. This on-line planning procedure enabled the completed operations plans to be translated directly into defensive combat directives. Thus, the SIMTOS G-3s were allowed to execute their own defense during the combat segment of the scenario.[5]

Decision support for the revised planning procedure consisted of three adaptive components of estimate of the situation-type aiding.[6] Each component was designed to be responsive to a bipolar dimension of decision style. For the active/passive dimension of decision style, a time pacing aid was developed. Approximate times to complete each step and the overall plan were established and displayed on the auxiliary CRT. As the G-3 developed his plan, the time spent on each step was recorded and also displayed. Active styles hypothetically hurry the planning process, while passive styles prolong it. By comparing progress with an appropriate standard, each decision style should be able to develop their own planning schedule and priorities.

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[5] For the "unaided" G-3 participants (the control group), planning was completed off-line. However, the six tactical step format was imposed on the paper and pencil task. The experimenter interpolated the resultant plans in terms of the on-line planning alternatives and then entered them on-line. Thus, the unaided G-3s also executed their own defense. The complete experiment procedure is contained in Appendix 1, Handbook for Research in a SIMTOS, of this report.

[6] The system operation description of how these aids work is contained in Appendix 2, Decision Aiding Software Specifications, of this report.

For the abstract/concrete dimension of decision style, a data base information retrieval aid was developed by linking planning activities to information in the SIMTOS data base. Abstract styles presumably lose sight of the immediate task by attempting to integrate the "bigger picture." Thus, the transfer was designed to place the abstract styles into the appropriate area of the data base where they could search to find the relevant information. Concrete styles, on the other hand, presumably lose sight of the immediate task through assimilation of too many details. For the concrete styles, the transfer was thus designed to directly provide the relevant information without further search.

The logical/intuitive component of the planning decision support system was an order of tactical planning aid. Intuitive style types could complete the tactical planning steps in any order--a procedure consistent with their presumed preference for correlative/associative information processing. Logical style types had to complete the tactical planning steps in a preselected (doctrinal) sequence. This procedure is consistent with presumed logical style preferences.

Three system modifications (described in Appendix 2 of this report) were made to the combat segment of the SIMTOS defensive scenario. While enhancing the SIMTOS human/computer dialog, they did not directly affect the nature of combat decision support. The complex for combat consisted of a previously incorporated, normative resource allocation aid and an estimate of the situation aid in both a normative and adaptive form.

The resource allocation aid provided a list of artillery and tactical air units within striking range of a specified target location. The G-3 consultants could then designate the units, and the amount of weapon expenditure committed to firing on the target. Thus, the G-3 had convenient control authority over his tactical response resources.

An estimate of the situation aid in the form of unit status boards was also developed for combat. The unit status board, which provided current summary information (via the auxiliary CRT display) on both friendly and enemy units, was expected to aid the G-3 in assessing the current tactical situation. The status board contained a list of unit names followed by columns for location, mission, strength, situation, and contact. If the status of a unit changed, a box appeared under the column heading indicating which specific information changed. Detailed information on the unit could then be displayed at the bottom of the board. For the normative aid, the units contained on the status boards were predetermined. While not geared to a specific decision style dimension, the aid was adaptive to the extent that content could be selected by the individual G-3.

Summary

Modifications were integrated into the SIMTOS for the present experiment program to make the scenario more indicative of G-3 decision tasks and the decision support system more responsive to these tasks. Table 1 presents a summary of the SIMTOS decision support system.

Table 1

SIMTOS Decision Support System

Planning Aids
• Data base information retrieval (adaptive)
• Time pacing (adaptive)
• Order of tactical planning (adaptive)
Combat Aids
• Estimate of the situation - status board (adaptive)
• Resource allocation (normative)
Human/Computer Dialog Aids
• On-line operations planning
• Translation of plan into combat phase
• Re-organization at battalion level eliminated
• Mission change process simplified
• Automatic directives for GOP force movement

Purpose of the Present Experiment

The SIMTOS decision support system was designed to explore alternative techniques for aiding the tactical decision maker in an automated command and control environment. It blends adaptive and normative aids into a system that should increase G-3 effectiveness and satisfaction with an automated system. The present experiment sought to establish relationships between decision support procedures, tactical information processing, and tactical performance.

In general, evaluation of the decision support system was based on the assumption that the use of decision support techniques would enhance information processing in an automated tactical data system and result in an increase in tactical performance. To evaluate the degree to which the decision support system met this assumption, the following hypotheses were investigated:

- Operation plans developed with decision support would result in better tactical performance than operation plans developed without decision support.
- Decision support would be beneficial to the gathering, processing, and selection of information with respect to the development of the operation plans.
- Use of the combat unit status boards would be reflected in improved tactical performance.
- Use of the resource allocation aid would improve tactical performance.
- User satisfaction with the automated tactical system would be increased through application of decision support.

Analysis methods to test these hypotheses employed information processing measures and tactical performance measures defined in the next section.

METHOD

PARTICIPANTS

Thirty-seven Army officers participated in the experimental evaluation of decision support in SIMTOS. Twenty-five participants were assigned to experiment groups and 12 were used for experiment procedure and SIMTOS checkouts. All SIMTOS study participants were graduates of the Command General Staff College (Ft. Leavenworth, Kansas) and had Battalion or Division G-3 experience.

The Army Military Personnel Division supplied ARI with a list of officers assigned to the Pentagon who met the experiment requirements. ARI then selected three Pentagon offices (DCSOPS, DCSPER, and DSRADA) which would serve as the experiment population. An agreement to provide participant support was obtained from the Commanding Officers of these offices. Each office then prepared a list of available personnel. The participant sample was drawn from these lists. Using this procedure, 21 participants were drawn from DCSOPS, nine from DCSPER, and seven from DSRADA.

Table 2 presents background of the 25 Army officers who participated in the experiment proper.

PROGRAM ENVIRONMENT--THE SIMTOS

The G-3 component of the defensive scenario of ARI's SIMTOS was used in this experiment. The SIMTOS is a man-in-the-loop computer supported

Table 2

Army Participant Biographical Data By Experiment Groups

Group / Data	General Aided n = 10	Adaptive Aided n = 10	Unaided n = 5
Rank	Lt. Colonels-7 Majors-3	Lt. Colonels-8 Majors-2	Colonel-1 Lt. Colonel-3 Majors-1
Average Age	38.7 years	40.6 years	40.6 years
Average Service	18.2 years	18.5 years	18.5 years
Average Combat	19.6 months	19.8 months	22.2 months
Average Since CGSC Graduation	5.0 years	4.6 years	7.2 years
With G-3/Ops Experience	90%	100%	100%
With Tactical Map Exercises (Germany)	33%	33%	20%
Education	Bachelors-10 Masters-4 Some graduate work-3	Bachelors-10 Masters-0 Some graduate work-4	Bachelors-5 Masters-3 Some graduate work-0
Army Branch	Infantry-6 Chemical Corps-1 Field Artillery-3	Infantry-3 Armored-2 Field Artillery-4 Armored Cavalry-1	Infantry-3 Armored-1 Field Artillery-1

simulation designed to provide an environment for the study of tactical information processing and decision making. The SIMTOS consists of software and hardware capable of executing and collecting data on a scenario in which a defense of the Hof Gap in Germany can be developed and implemented. The role of the SIMTOS participant is that of the division G-3 (operations officer) for the U.S. Army's 20th Mechanized Division. His task is to use the SIMTOS to plan his defense (planning segment) and to respond with his tactical resources as the enemy's 16th Combined Arms Army attacks his sector (combat segment).

The SIMTOS hardware configuration used in the experiment is detailed elsewhere (Bunker-Ramo, 1973 and Levit et al., 1974). The SIMTOS software was modified so that the decision support system could be integrated. The decision support specifications and associated software changes are included in this report as Appendix 2, Decision Aiding Software Specifications.

The participant's environment consisted of a station containing those elements necessary to allow interaction with the computer system and to support his task performance. The station contained two Control Data Corporation-211 CRT displays, an International Business Machine teletypewriter, a work table, a 24-hour clock (run at three times real time), and standard 1:50,000 and 1:250,000 tactical map of the Hof Gap area for which avenue of approach and key terrain overlays were available. Unit identification stickers for friendly and enemy forces were posted on the tactical map. Participants in the general and adaptive aided groups used both CRT displays. Participants in the unaided group used only one.

PROCEDURAL SUMMARY[7]

Two Army officers participated in the experiment simultaneously, but independently. Figure 1 depicts the experiment schedule. Each experiment day began with an introductory briefing explaining the SIMTOS environment and the general nature of the experiment program. After this briefing, both aided and unaided subjects completed the Decision Style Measurement Instrument (DSMI).[8] After completing the DSMI, the experimenter introduced the SIMTOS G-3 tasks and explained the nature of the planning segment activities. The SIMTOS G-3 then completed the planning segment activities. After a 30 to 45 minute break, the experimenter briefed the participant on the SIMTOS combat segment. After this explanation, the participant completed the combat segment. The experiment day ended with each participant receiving a debriefing on the purpose of the experiment. Each participant filled out a user satisfaction/debriefing questionnaire.

EXPERIMENTAL DESIGN AND VARIABLES

Twenty-five participants were randomly assigned to three experiment groups. Each experiment group differed as to the level and type of decision support available. An adaptive group used a decision support system tailored to the participant's decision style. A general aided group used a decision

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[7] A complete description of experiment procedure and materials is contained in Appendix 1, Handbook for Research In A SIMTOS, of this report.

[8] A discussion of the development of the DSMI is contained in Levit et al., Volume 2, 1974.

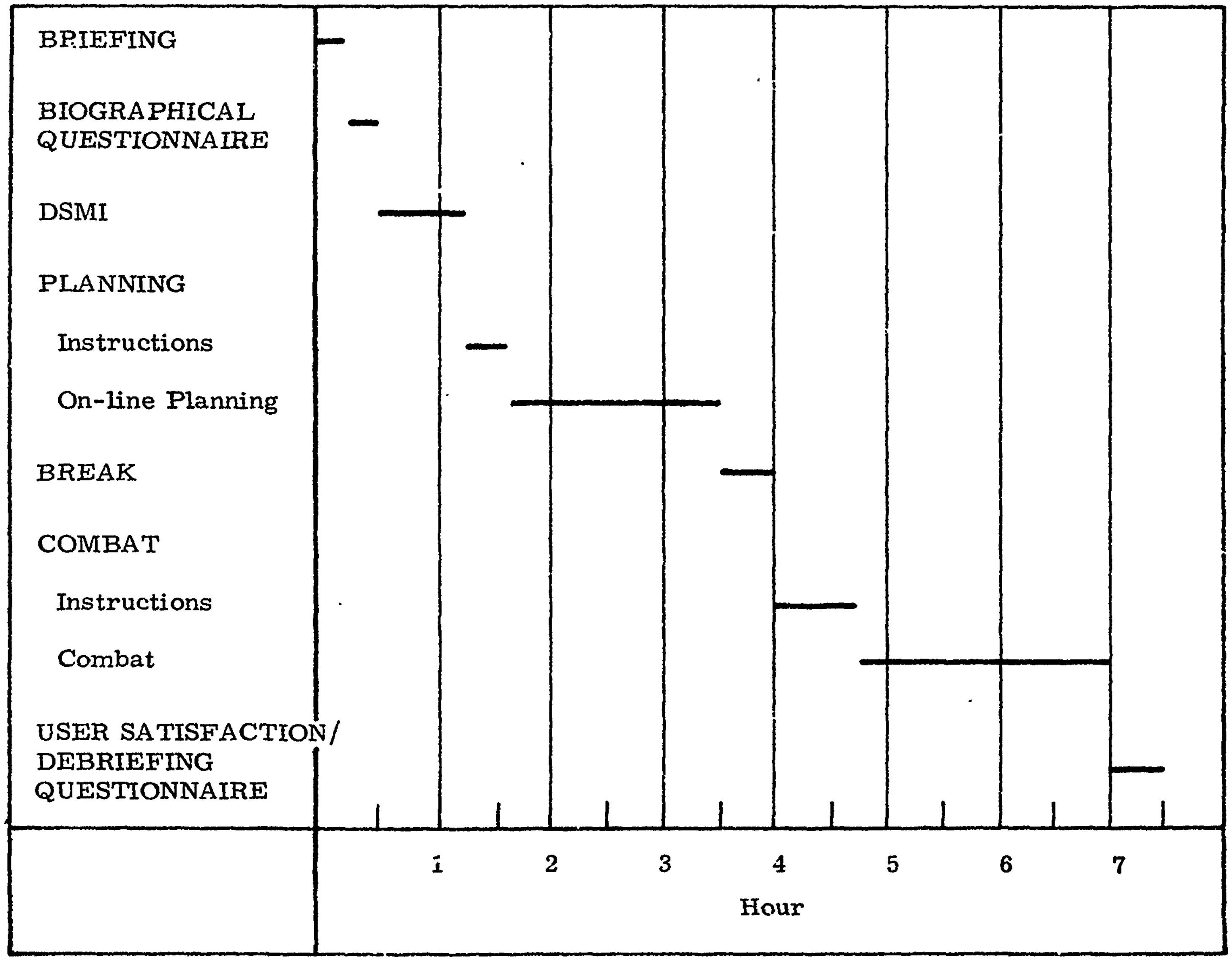

Figure 1. Procedural time schedule

support system tailored to a modal decision style.[9] An unaided (control) group did not have the benefit of complete decision support. Ten participants were assigned to each of the aided groups, five were assigned to the unaided group.

Independent Variables

The primary independent variable was the type of decision support available to participants in each of the three experiment groups. The participants in both aided groups used the on-line planning format. In the adaptive aided condition, the form of the planning estimate of the situation aids was determined by the decision style of each participant. In the general aided condition, the form of the planning estimate of the situation aids for all the particpants was based on the Active/Abstract/Intuitive decision style. In the unaided condition, the participants developed their operations plan off-line and no planning aids were provided.

The participants in both aided groups had the unit status boards (the estimate of situation aid) and the resource allocation aid available for use during the combat segment. The participants in the adaptive aided condition selected the content of their status boards, while the content for the participants in the general aided condition was preselected. The participants in the

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[9] Previous studies (Levit et al., Volume 3, 1974) of decision style in tactical populations indicates that the modal style is Active/Abstract/Intuitive.

unaided condition did not have the unit status boards, but had the resource allocation capability during combat.[10]

Dependent Variables

Tactical performance and information processing measures were used to evaluate G-3 performance and the contribution of decision support to that performance. The derivation of these measures is presented in Appendix 3, Data Recording Procedures and Derivation of Dependent Measures, of this report.

Each G-3's operations plan, developed during the planning session, was implemented as the defense for the combat session. Thus, tactical evaluation of the plans involved determining the effectiveness of the operations in combat.

Adaptations of five measures "determined to be of significant importance in assessing combat performance during defensive operations" (Bunker-Ramo, 1973) were used for evaluation of tactical combat performance.

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[10] A result of the preliminary evaluation experiment (Levit et al., Volume 3, 1974, p. 13), showed that the resource allocation had to be made available to the unaided group. Without this capability G-3 participants could not attain a minimum level of performance. While this fact is a verification of the need for careful design of interactive systems, the procedure substantially diluted the power of aided versus unaided statistical comparisons.

They were:

- Friendly force attrition
- Enemy force attrition
- Distance surrendered
- Friendly force weapon expenditure
- Friendly force air strikes expended.

In addition to tactical performance measures, a number of measures were used to evaluate information processing during the planning segment. They were:

- Time to complete the operations plan
- Data base frames queried
- Data base frames queried from a transfer
- Sources sought
- General Index queries
- Depth of query into the data base
- Transfer use
- Information acquisition efficiency
- Data frames accessed.

For combat, information processing measures consisted of proportion of time spent in, and number of uses of, each of the four following available task functions:

- Standing Request for Information (SRI)[11]
  - establish
  - review
- Unit Status Boards
  - establish friendly units
  - establish enemy units
  - review
- Resource Allocation
- Unit Location Change

Both tactical performance and information processing measures were used in the analysis described in the last part of this section.

ANALYSIS TECHNIQUES

Experimental data were reduced, analyzed, and evaluated separately for the planning and combat segments. Method of analysis consisted of descriptive statistics and appropriate analysis of variance techniques for each of the dependent variables among the experiment groups (unaided versus general aided versus adaptive aided) and among the decision style groups (Abstract/Active/Intuitive style versus all other styles). Multiple single factor analyses of variance for unequal sample sizes were performed on the planning

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[11] An SRI is a SIMTOS user option which allows information in the data base to be "tagged." Changes in the information thus tagged are reported to the user during the next information update period. Information update periods occurred every 10 minutes real time (30 minutes simulated time).

information processing data (Winer, 1962). The tactical and information processing measures from the combat segment were analyzed across updates using a p x q factorial analysis of variance for unequal sample sizes (Winer, 1962).[12]

In addition, the operations plans developed during the planning segment were summarized and a "modal" solution was derived for comparison with a "school" solution based on the Ft. Leavenworth Command General Staff College exercise. Conflicting results from the analyses posed questions concerning the suitability of tactical performance measures for evaluation of decision support concepts. Additional analyses were therefore performed on data from baseline or non-operator interaction combat runs derived from the summarized operations plans.

The data collected from the post-experiment questionnaire was also summarized and interpreted in qualitative form.

[12] Every 10 minutes real time (30 minutes simulated combat time) the computer interrupted combat for an update. An update was a short period of time (about 30-45 seconds) during which the computer modified the course of the battle according to the participant system interactions and the preset directives for the opposing forces. Variable values were summarized after each 2-hour segment of simulated combat or every fourth update. Analyses were thus conducted for variable values at the fourth, eighth and 12th updates.

RESULTS

OVERVIEW

Results of decision style measurement, the SIMTOS planning segment and the SIMTOS combat segment, are presented separately. Frequencies of the observed decision style types and the composition of the decision style groups for the analyses are presented in the decision style measurement section. For the planning segment, a summary of the operations plans and a comparison of their content is given. The results of information processing measures derived to examine the methods used in development of the plans are then presented. For the combat segment, the results of the measurement of tactical performance are reported.

In addition, findings from the baseline scenario runs are given in terms of the combat tactical performance measures. Comparisons of tactical performance between the different operations plans and between the actual versus the baseline runs are made. The results from the post-experiment questionnaire summary are also reported.

The results format consists of reporting the experiment and decision style groups means for the tactical performance and information processing measures. The results from the statistical analyses are reported where appropriate for clarification of observed trends in the means. A supplementary section with descriptions of the derivation of dependent measures is included in this report as Appendix 3.

DECISION STYLE MEASUREMENT

The form of the decision aids for the adaptive group was determined by the scores on the Decision Style Measurement Instrument (DSMI). At its present stage of development, the DSMI is presumed to provide a nominal indication of decision style on each of three bipolar dimensions: Active/Passive, Logical/Intuitive, and Abstract/Concrete. These three scales yield eight possible combinations of decision styles. The styles observed in the study sample are presented in Table 3 for each of the experiment groups.

A frequency plot of the scores on each of the dimensions (Figure 2) yielded four logical scores, 17 intuitive scores and four tied scores. Five concrete scores and 20 abstract scores, three passive scores and 22 active scores were also observed. Combining these scores by participant indicated that 56 percent of those tested could be categorized as Active/Abstract/Intuitive (AAI). To equate sample sizes for analysis purposes, the 14 AAI styles were considered as one decision style group (a modal style group) and the 11 remaining styles combined into a second decision style group (others).

Two of the tied scores in the logical/intuitive dimensions occurred in the adaptive group. These participants were randomly assigned to the logical style categoration to determine their form of decision support in the planning segment. The other ties occurred in the general and unaided groups and therefore assignment to a specific style dimension was not necessary. The concrete dimension for both these participants placed them into the "other" decision style group for analysis.

Table 3

Observed Decision Styles

Style Group \ Experiment Group		General n = 10	Adaptive n = 10	Unaided n = 5
Active/Abstract/Intuitive	14	6	5*	3
Active/Abstract/Logical	1	1	0	0
Active/Abstract/Tie**	2	0	2	0
Active/Concrete/Intuitive	3	2	1	0
Active/Concrete/Logical	0	0	0	0
Active/Concrete/Tie**	2	1	0	1
Passive/Abstract/Intuitive	0	0	0	0
Passive/Abstract/Logical	0	0	0	0
Passive/Concrete/Intuitive	0	0	0	0
Passive/Concrete/Logical	3	0	2	1
TOTAL N	25			

* The General Aiding condition was based on the modal style of Active/Abstract/Intuitive (AAI). These five adaptive aided participants thus had the same system configuration as those in the General Aided group.

** Ties indicate non-discrimination between poles of the logical/intuitive dimension.

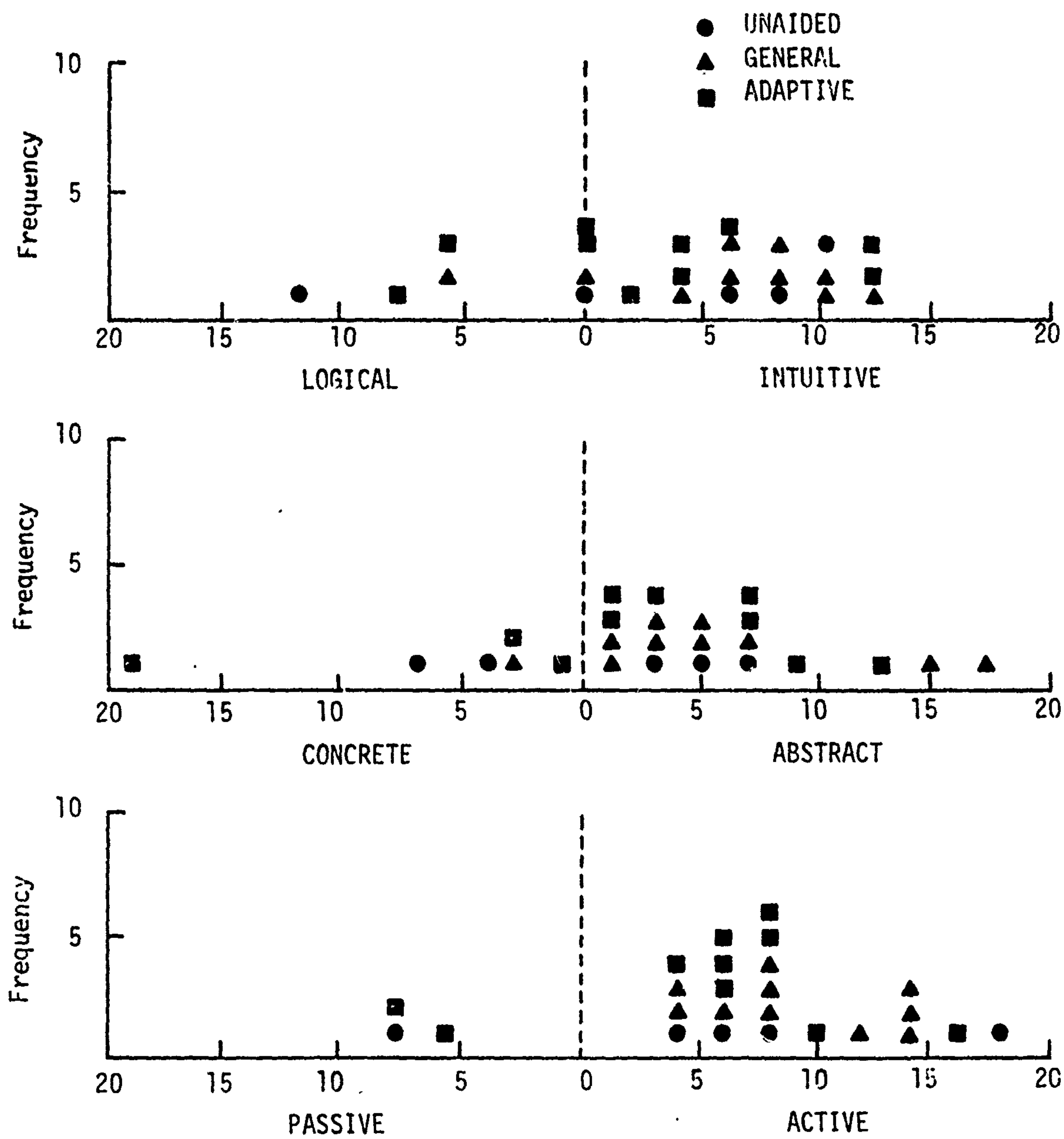


Figure 2. Observed DSMI difference scores: dimensions by experiment group

PLANNING: OPERATIONS PLANS

In the on-line operation planning format, three to five response alternatives were provided to the participants for each part of the six planning steps. For the written form, the number of alternatives was unlimited. Summaries of participant's plans showed that the total range of on-line planning alternatives was used by the aided G-3s, and that the choices made by the unaided G-3s (in the written form) fell within this range of alternatives.

A summary across all participants was made of the number of times an alternative was selected for each step part. A modal selection for each step part was thus derived. These selections were then combined to form a "modal" solution for the operations plan. Table 4 shows this modal plan and also a school solution for the defensive scenario in the Hof Gap.

In addition, the complete operations plan of one participant from each of the experiment groups is presented. Each of these plans differ significantly on one or more aspects from the modal and/or school solutions. They were thus chosen to emphasize the extensive individual variability observed in the planning segment of the scenario.

The general quality of the operations plans could be evaluated in terms of their fidelity to doctrine, their relation to the school solution, etc. However, as with any case of professional judgment, there is room for disagreement even among the most highly qualified experts. Therefore, no qualitative assessment of the plans will be made here. Rather, comparisons between the content of the plans to illustrate the probable differing operational tactics involved are given in the next paragraphs.

Table 4

Illustrative Operations Plans for SIMTOS Planning Segment

Step / Plan	Modal Solution	School Solution	Adaptive Aided Participant	General Aided Participant	Unaided Participant
1. Define Rear and Lateral BDE Boundaries and COP Coordinating Point:					
Rear Boundary*	Center	East	Center	Center	East
Lateral Boundary*	Center	Center	North	Center	Center
COP Coordinating Point	[illegible] KM forward of the FEBA	2 KM forward of the FEBA	3 KM forward of the FEBA	4 KM forward of the FEBA	5 KM forward of the FEBA
2. Assign BDE Sectors of Operation:**					
1/20 BDE	North	North	North	North	North
2/20 BDE	South	South	South	South	South
3/20 BDE	Rear	Rear	South	Rear	Rear
20 DIV TRP	Rear	Rear	Rear	Rear	Rear
3. Define Allowable Enemy BN Penetration:					
Avenue of Approach A	2 KM back of FEBA	1 KM back of FEBA	.5 KM back of FEBA	2 KM back of FEBA	2 KM back of FEBA
Avenue of Approach B	2 KM back of FEBA	2 KM back of FEBA	1 KM back of FEBA	2 KM back of FEBA	2 KM back of FEBA
Avenue of Approach C	2 KM back of FEBA	.5 KM back of FEBA	.5 KM back of FEBA	2 KM back of FEBA	2 KM back of FEBA
4A. Allocate Combat Power to Echelon of Defense:					
GOP Units Supplied By	3/20 BDE (Rear)	3/20 BDE (Rear)	1/20 BDE (North)	3/20 BDE (Rear)	3/20 BDE (Rear)

* The three alternatives for defining the placement of each boundary were given as sets of end-point map coordinates. As these coordinates are meaningless without the tactical map reference, their placement in respect to each other within the division sector is given. Thus the choices for the Rear Boundary would be West, Center, or East and the choices for the Lateral Boundary would be North, Center, and South.

** These brigade sectors are defined by the Lateral and Rear Boundaries.

Table 4

Illustrative Operations Plans for SIMTOS Planning Segment (Concluded)

Step	Plan		Modal Solution		School Solution		Adaptive Aided Participant		General Aided Participant		Unaided Participant	
4B.	Allocate Combat Power to Echelon of Defense - BN to BDE:											
	Sector	Unit Type	No.	GOP	No.**	GOP	No.	GOP	No.	GOP	No.	GOP
	North	Mech.	3		3		2	2	3		2	
		ARM	1		1		3	2	1		1	
		8"	1		0		1	1	0		0	
		155 mm	1		1		2	1	2		0	
		HJ	0		0		0	0	0		0	
		ADA	0		0		0	0	0		0	
		Total No. of Units	6		5		8	6	6		3	
	South	Mech.	3		3		5		3		2	
		ARM	1		1		0		0		1	
		8"	0		0		2		0		0	
		155 mm	2		1		4		2		0	
		HJ	0		0		2		0		0	
		ADA	0		0		1		0		0	
		Total No. of Units	6		5		14		5		3	
	Rear	Mech.	1	1	1	0	0		1	1	3	1
		ARM	2	2	2	2	1		3	3	2	1
		8"	2	1	1	1	0		3	3	3	3
		155 mm	3	1	2	2	0		2	2	6	0
		HJ	2	0	2	0	0		2	0	2	0
		ADA	1	0	1	0	0		1	0	1	0
		Total No. of Units	11	5	9	5	1		12	9	17	5
5.	Assign GOP Force Location: GOP Force		19 KM forward of the FEBA		13 KM forward of the FEBA		8 KM forward of the FEBA		19 KM forward of the FEBA		8 KM forward of the FEBA	
6.	Assign BDE Missions:	1/20 BDE	Defend	(North)	Defend	(North)	Defend	(North)	Defend	(North)	Defend	(North)
		2/20 BDE	Defend	(South)	Defend	(South)	Defend	(South)	Defend	(South)	Defend	(South)
		3/20 BDE	Reserve	(Rear)	Reconnoiter	(Rear)	Defend	(South)	Reserve	(Rear)	Reserve	(Rear)
		DIV TRP	Reserve	(Rear)	Reconnoiter	(Rear)	Reserve	(Rear)	Screen	(Rear)	Reserve	(Rear)
		GOP	Delay		Delay		Delay		Delay		Screen	

* GOP force units represent a sub-set of the total units assigned to a sector. After the GOP force has fallen back they become assigned to the particular sector.

** The school solution assigns two 8" BN and two 155 mm BN to a general support role. This was not an option in the on-line plan.

The major differences between the modal plan and the school solution occurs in the placement of the Combat Outpost (COP) and General Outpost (GOP), and in the brigade missions. In the modal plan, the COP and GOP are located 5 kilometers and 19 kilometers in front of the Forward Edge of the Battle Area (FEBA) respectively, opposed to 2 kilometers and 13 kilometers in the school solution. The modal plan assigns reserve missions to its rear forces, while the school solution assigns a reconnoiter mission.

According to the Department of the Army Field Manual (The Infantry Battalions, FM7-20, 1969), the GOP and COP are security elements used to alert the defensive units of the enemy's approach, and to attempt to discourage or deceive the enemy as to the true location of the friendly forces. Their location should thus impact the timeliness of the warning and ability to successfully deceive the enemy. For both these elements, the decision for their placement should be based upon selection of an optimal distance from the FEBA using the best available terrain from which they can accomplish their mission. The modal plan places the GOP and COP in positions where earlier contact will be made with the enemy.

The assigned mission determines the tactics of operation employed by a unit (in this case, the brigade). The reconnoiter mission assigned to the rear forces in the school solution could indicate that these forces would be used initially to help discover and test the enemy's strengths and weaknesses (Department of the Army Field Manual, The Infantry Brigades, FM7-30, 1969). This would typically be a limited objective operation after which the force could return to the rear to provide or reinforce the reserve. In the modal solution, the reserve mission assigned to the rear forces could indicate that these forces would not be used until or unless the enemy attack is of such magnitude that assistance is needed to contain the enemy's penetration.

The individual participant plans from each experiment group have their unique characteristics in terms of COP and GOP placement; brigade location, mission and make-up, and GOP force composition. The participant from the adaptive aided group places two brigades in the South, yet assigns most of his battalion strength to the North. His plan also places the GOP close to the FEBA and assigns them to a forward brigade rather than to the rear. The participant from the general aided group assigns a large GOP force and positions it as close to the enemy as possible. Most of the available forces in the plan of the participant from the unaided group are assigned to rear. In addition, this participant assigns a screen mission to his GOP force.

The results on tactical performance from implementation of the operation plans for the defensive combat segment of the SIMTOS G-3 scenario is presented in the combat and baseline runs sections below.

PLANNING: INFORMATION PROCESSING MEASURES

Nine measures of information processing were derived from the planning segment. They were:[13]

- Time to complete operations plan
- Data base frames queried
- Data frames accessed
- General Index queries
- Transfer use
- Data base frames queried from a transfer

[13] The derivation of these measures is given in Appendix 3 of this report.

- Sources sought
- Depth of query into the data base
- Information acquisition efficiency.

The cumulative planning completion times among experiment groups and decision style groups is presented in Figures 3 and 4. While Step 1 ($F = 56.6$, $df = 5/108$, $p < .01$) and Step 4 ($F = 54.49$, $df = 5/108$, $p < .01$) took significantly longer to complete than the other steps, there were no significant time completion differences among the experiment or decision style groups. Because the unaided group did not complete the plan on-line, step-by-step completion time was not recorded. Overall planning time for this group is recorded as a point in Figure 3. The unaided group completed the plan 10 minutes faster (on the average) than the aided groups.

Table 5 contains the mean number of frames queried, data frames reached, general index queries, transfer use and frames from the transfer by experiment group and decision style Group. The unaided group and the general aided groups queried significantly more total frames ($F = 14.91$, $df = 2/24$, $p < .01$) and reached more data frames ($F = 19.79$, $df = 2/24$, $p < .01$) than the adaptive group. The transfer option was used by only 12 of the 20 aided participants and use ranged from one to ten instances. No significant differences were observed among experiment or decision style groups on this measure.

The total frames queried were compared with the total data frames accessed to provide an indicator (depth of query ratio) of how far into the data base hierarchy the participants had to search before finding the information desired. Total data frames were divided by the number of entries into the data base

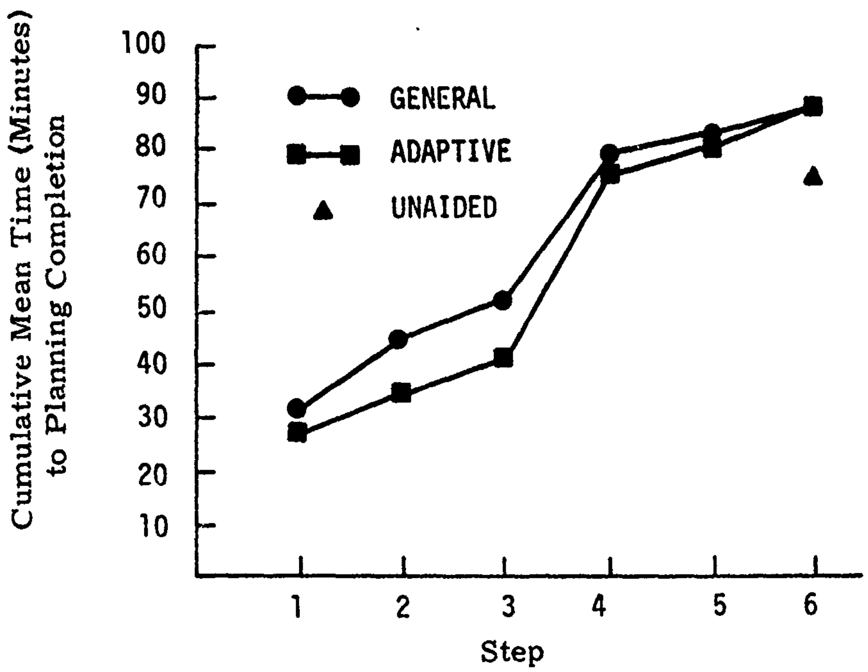


Figure 3. Time to complete operations plan: cumulative mean times by experiment group

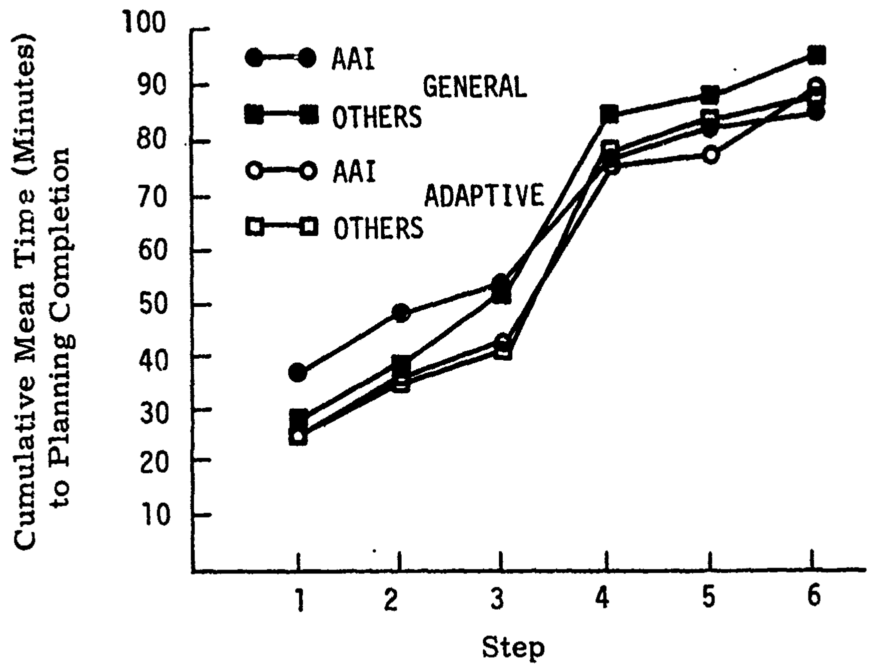


Figure 4. Time to complete operations plan: cumulative mean times by AAI versus others within experiment group

Table 5

Planning: Information Processing Measures By Experiment and Decision Style Groups

Measure \ Group	Unaided n = 5	General Aided n = 10	Adaptive Aided n = 10	AAI n = 14	Other n = 11
Frames Queried	181.80	92.00	50.50	104.13	77.20
Data Frames Reached	68.20	32.50	15.90	37.30	26.50
General Index Queries	16.80	13.00	6.40	12.47	9.60
				n = 12	n = 8
Transfer Use*	--	6.60	5.50	4.25	8.75
Frames from Transfer*	--	3.20	2.80	2.00	4.50

* Unaided participants are not included in the analysis of these measures. This lowers the n's in the decision style groups.

(either via the general index or by the transfer) to derive the information acquisition efficiency ratio. The means by experiment groups for these ratios are given in Table 6.

Table 6

Planning Information Processing Measures: Data Base Query for Experiment and Decision Style Groups

Measure \ Group	Unaided Aided n = 5	General Aided n = 10	Adaptive Aided n = 10	AAI n = 14	Other n = 11
Depth of Query Ratio	2.67	2.83	3.18	2.44	2.52
Acquisition Efficiency Ratio	4.06	2.50	2.30	2.93	4.77

The depth of query into the data base was highest for the adaptive group, and almost equal for the general aided and unaided groups. However, the unaided groups, acquisition ratio was greater than either of the other two groups. The depth of query into the data base was about equal for the decision style groups. However, the "other" decision style groups' acquisition ratio was greater than that of the AAI group.

The mean number of the sources sought by experiment group and decision style group by SIMTOS data base category are shown in Table 7. The unaided and general aided groups sought significantly more pieces of information from each category than did the adaptive group ($F = 5.79$, $df = 2/220$, $p < .05$), but no significant differences were found in the amount of information sought from each category between the decision style groups. A significant difference between data base categories sought was found ($F = 26.46$, $df = 9/220$, $p < .05$). The information contained in the G-1 personnel category, G-2 intelligence category, and the G-3 operation category was accessed more frequently than information in the other categories.

Table 7

Planning Information Processing Measures: Sources Sought for Experiment and Decision Style Groups

Data Base Category \ Group	Unaided n = 5	General Aided n = 10	Adaptive Aided n = 10	AAI n = 14	Other n = 11
1-Personnel	2.2	1.5	1.6	1.50	1.70
2-Intelligence	4.4	5.1	4.1	3.80	4.60
3-Operations	4.6	5.1	2.5	3.80	4.20
4-Logistics	1.4	0.7	0.4	1.00	0.30
5-Civil Affairs	0.4	0.5	0.1	0.30	0.30
6-Fire Support	2.0	1.1	0.5	1.27	0.70
7-Chemical and Biological	0.2	0.4	0.0	0.20	0.20
8-Signal	0.4	0.4	0.1	0.27	0.30
9-Transportation	0.2	1.0	0.2	0.60	0.40
10-Engineering	1.0	0.4	0.2	0.40	0.50

COMBAT: TACTICAL MEASURES

The five measures of tactical performance derived from the combat session are as follows:[14]

- Friendly force attrition
- Enemy force attrition
- Friendly force weapon expenditure
- Friendly force tactical air strikes expended
- Distance surrendered.

Friendly force weapon expenditure was allocated by weapon type: Type 1-15mm artillery; Type 2-8 inch artillery; Type 3-Honest John missile. Attrition and expenditure are reported as loss percentages. These percentages are based upon the initial strength (i.e., 100 percent) with no reinforcement or resupply. Distance surrendered is defined in terms of kilometers of penetration from the international border.

Tables 8 and 9 contain the means and standard dev tions for these measures for experiment and decision style groups across three update periods. In addition, means from the modal baseline (defined in the baseline scenario runs section) are reported for comparison. No significant differences were found between the groups on percent of friendly force attrition, percent of enemy force attrition, percent of friendly force tactical air strikes expended, distances surrendered (kilometers) or percent of weapon Type 1 and weapon Type 2 expenditures. The unaided G-3s did expend significantly more HJs (Type 3) than either the general or adaptive aided groups in the first four updates ($F = 5.57$, $df = 2/24$, $p < .05$). This effect occurred because only

[14] The derivation of these measures is contained in Appendix 3 of this report.

Table 8

Combat Tactical Measures: Experiment Groups and Modal Plan Baseline By Update--Means and Standard Deviations

Measure and Experiment Group / Update	4th Mean	4th SD	8th Mean	8th SD	12th Mean	12th SD
Friendly Attrition (%)						
Unaided	10.4	4.6	22.8	6.3	27.5	5.9
General	9.1	2.0	20.8	3.3	25.3	3.1
Adaptive	7.5	2.3	19.4	5.0	23.6	5.0
Modal Baseline	6.9	-	17.0	-	20.6	-
Enemy Attrition (%)						
Unaided	2.3	0.7	6.3	0.8	11.2	2.6
General	1.9	0.8	6.3	1.8	11.7	4.0
Adaptive	1.8	0.5	6.7	2.1	11.9	3.5
Modal Baseline	0.7	-	3.4	-	6.3	-
Weapon Expenditure (%)						
Type 1						
Unaided	10.9	0.3	30.0	1.1	56.0	2.0
General	11.1	1.5	38.0	3.3	55.0	3.5
Adaptive	13.5	1.3	40.0	2.4	59.0	2.0
Type 2						
Unaided	21.4	2.0	37.0	1.7	46.0	1.4
General	17.4	2.7	32.0	3.0	55.0	3.3
Adaptive	7.5	1.0	26.0	2.4	44.0	3.5
Type 3						
Unaided	15.0	0.8	26.0	1.4	35.0	2.3
General	4.0	0.5	14.0	1.3	29.0	2.6
Adaptive	7.0	0.6	20.0	1.3	36.0	2.2
Tactical Air Strike Expenditure (%)						
Unaided	21.2	11.8	36.8	23.4	44.8	28.8
General	14.2	11.4	38.0	27.5	57.7	36.2
Adaptive	17.0	12.9	38.6	19.4	56.2	25.9
Distance Surrendered (km)						
Unaided	9.3	.8	22.0	2.3	27.6	1.2
General	8.8	.9	21.7	1.2	26.8	1.2
Adaptive	8.9	.9	22.1	1.0	26.6	.9
Modal Baseline	9.8	-	22.8	-	26.0	-

Table 9

Combat Tactical Measures: Decision-Style Groups and Modal Plan Baseline By Update--Means and Standard Deviations

Measure and Decision Style Group \ Update	4th Mean	4th SD	8th Mean	8th SD	12th Mean	12th SD
Friendly Attrition (%)						
AAI	8.9	2.4	19.6	3.7	24.0	3.5
Others	8.5	3.6	22.1	5.8	26.7	5.6
Modal Baseline	6.9	-	17.0	-	20.6	-
Enemy Attrition (%)						
AAI	2.0	0.6	7.1	1.7	11.8	3.6
Others	1.8	0.9	5.7	1.4	11.4	3.5
Modal Baseline	0.7	-	3.4	-	6.3	-
Weapon Expenditure (%)						
Type 1						
AAI	13.0	1.3	43.0	2.6	56.0	2.7
Others	9.0	1.1	28.0	2.4	58.0	2.5
Type 2						
AAI	17.0	2.2	33.0	2.5	51.0	3.3
Others	9.0	1.7	27.0	2.5	46.0	2.7
Type 3						
AAI	7.0	0.6	19.0	1.2	32.0	2.6
Others	8.0	0.9	18.0	1.6	35.0	1.9
Tactical Air Strike Expenditure (%)						
AAI	17.2	10.2	38.4	22.9	55.2	34.3
Other	16.0	14.6	37.3	23.7	53.5	24.2
Distance Surrendered (km)						
AAI	9.2	.8	22.1	1.4	26.9	1.0
Other	8.6	.8	21.6	1.1	26.9	1.4
Modal Baseline	9.8	-	22.8	-	26.0	-

eight of the 20 aided G-3s had used HJs by that point. As combat continued, the aided G-3s also began to expend this weapon type. No significant difference was found between groups by either the eight or twelfth update.

Thus, the tactical performance differences among the experiment and decision style groups are extremely small. For example, a graph of the cumulative mean distance surrendered is given in Figure 5. The curves for the unaided, general aided, and adaptive aided groups are almost identical across updates. Even the minor variance within groups on the tactical measures produced large error terms, causing the analysis of variance $\underline{F}$ values to be very small.

In summary, the tactical measures show no combat performance differences between groups. The implications of this finding for the decision support and the SIMTOS defensive scenario are discussed in a later section of this report.

COMBAT: INFORMATION PROCESSING MEASURES

Analysis of combat information processing consisted of examining the use of the system interaction functions available to the G-3 during the combat session. Use of each of these functions was measured in two ways: frequency of use and length of time used. These measures were derived for:

- SRIs
- Status Boards
- Resource Allocation
- Unit Location Change.

Table 10 shows the mean frequency of use for each function by experiment and decision style groups across updates. The mean percent of available time

Table 10

Combat Information Processing Measures: Experiment and Decision Style Groups By Update--Mean Frequency

Measure and Group \ Update		4th	8th	12th	Decision Style Group	4th	8th	12th
SRI Establish								
Unaided		22.8	2.0	3.8	AAI	13.8	1.6	1.5
General		19.8	0.1	0.0	Other	21.5	0.7	0.2
Adaptive		11.0	2.0	0.0				
SRI Review								
Unaided		26.4	18.0	9.0	AAI	8.2	5.9	4.0
General		5.1	1.4	4.7	Other	10.4	4.7	6.0
Adaptive		4.4	3.2	2.8				
Status Board Establish								
Friendly	General	0.9	0.1	0.1	AAI	8.6	0.8	0.3
	Adaptive	14.5	2.2	2.4	Other	6.4	1.7	1.8
Enemy	General	3.0	0.2	0.0	AAI	16.8	0.8	0.2
	Adaptive	12.6	1.3	0.7	Other	6.6	1.1	0.6
Status Board Review								
General		20.8	17.9	23.3	AAI	24.2	18.5	28.0
Adaptive		20.1	14.6	20.7	Other	14.8	12.9	12.0
Resource Allocation								
Unaided		13.0	12.4	8.0				
General		14.2	15.5	13.4	AAI	15.6	14.1	11.6
Adaptive		12.8	12.0	12.2	Other	10.9	12.6	12.2
Unit Location Change								
Unaided		2.0	1.4	2.2	AAI	1.5	2.7	3.1
General		1.0	3.2	3.4	Other	1.2	3.2	3.1
Adaptive		1.5	3.1	2.0				

Table 11

Combat Information Processing Measures: Experiment and Decision Style Groups by Update--Percent Time Spent on Function

Measure and Group \ Update	4 %	8 %	12 %	Decision Style Group	4 %	8 %	12 %
SRI Establish							
Unaided	30	16	17	AAI	17	5	8
General	27	3	0	Others	28	12	6
Adaptive	18	9	0				
SRI Review							
Unaided	36	41	31	AAI	17	13	11
General	13	9	7	Others	18	14	12
Adaptive	7	3	6				
Status Board Establish							
General	8	5	2	AAI	14	4	3
Adaptive	28	7	7	Others	14	8	6
Status Board Review							
General	13	20	27	AAI	21	23	33
Adaptive	18	24	26	Others	20	21	16
Resource Allocation							
Unaided	26	33	20	AAI	36	38	28
General	28	37	32	Others	24	33	30
Adaptive	23	37	31				
Unit Location Change							
Unaided	5	11	28	AAI	7	22	20
General	6	26	27	Others	3	18	30
Adaptive	6	20	20				

spent using each function across updates for the experiment and decision style groups is presented in Table 11. Although there were no significant differences among the experiment groups and decision style groups on the number of SRIs established, there were significant time differences.

The unaided group spent significantly more time establishing SRIs than did the general and adaptive aided groups ($F = 3.89$, $df = 2/66$, $p < .05$) and the "other" decision styles group spent significantly more time establishing SRIs than did the AAI group. The unaided participants reviewed significantly more SRIs ($F = 64.81$, $df = 2/66$, $p < .05$) and thus spent significantly more time reviewing SRIs ($F = 94.71$, $df = 2.66$, $p < .05$) than either general aided or adaptive aided participants. Since the unaided group had only the SRI function for monitoring, these differences are a product of the nature of the task. However, no significant differences were found between the decision style groups on the number of SRIs reviewed or on the amount of SRI review time.

Significantly more time was spent by the adaptive group establishing status board units than was spent by the general group ($F = 12.14$, $df = 1/54$, $p < .05$). The adaptive group also established significantly more friendly ($F = 15.03$, $df = 1/54$, $p < .05$) and enemy ($F = 34.34$, $df = 1/54$, $p < .05$) units on the status boards than did the general group. However, there were no significant differences between these groups in either number of reviews or amount of time spent reviewing the units' status once the units had been placed on the boards.

No significant differences were found between the decision style groups on establishing the status boards. Also, no differences were found between the decision groups in the time spent reviewing the status boards. The AAI G-3s though, reviewed significantly more units from the status boards than

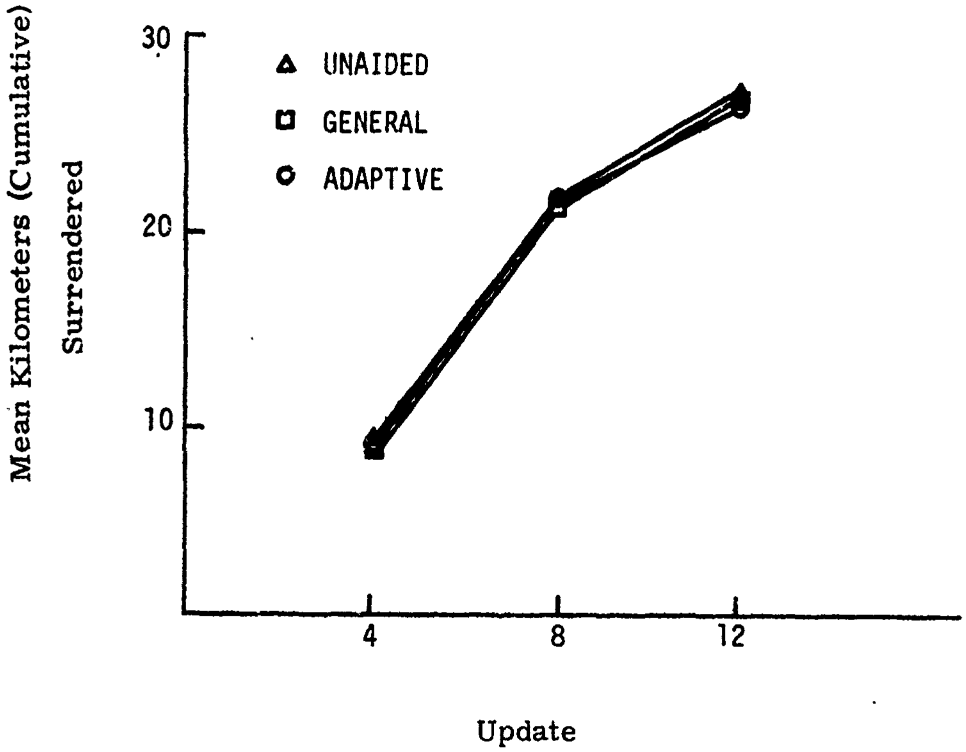


Figure 5. Combat tactical measures: cumulative mean distance surrendered for experiment groups across updates

did the "other" decision style G-3s ($F = 6.90$, $df = 1/54$, $p < .05$). No significant differences in frequency or time measures were observed among experiment or decision style groups for the resource allocation and unit location change options.

Significant update effects were found in the experiment groups in the frequency and time measures for SRIs established, SRIs reviewed, and status board units established. For the decision style groups, significant update effects were found in the frequency and time measures for SRIs established and status board units. These update effects are due to the frequent use of these functions early in the exercise, followed by a sharp decrease in use later in the exercise. No significant update effects were found among experiment or decision style groups for the review of status board units or the resource allocation option. Use of these functions thus remained at a constant level throughout the exercise. As combat progressed however, all groups significantly increased their frequency of use of the unit location change function.

BASELINE SCENARIO RUNS

As stated previously, large variations existed in the development and the resultant content of the operations plans completed by the SIMTOS G-3s. Also, there were few significant differences in how the G-3s interacted with the system during combat. Yet no differences were found in the measures of tactical performance associated with the SIMTOS defensive combat segment. To more closely examine this apparent discrepancy, a number of nonoperator interaction or baseline combat runs were made.

Each of the five plans summarized in Table 4 were input as the defensive operations plan for combat. These five plans include a modal solution from summarization of all plans, a school solution, and one illustrative plan from each experiment group. The G-3 defensive scenario was then executed with no operator interaction for a simulated 12-hour combat session. The status of the scenario was summarized every fourth update as in the experiment runs. The combat tactical performance measures of percent of friendly force attrition, percent of enemy force attrition, and distance surrendered (kilometers) were derived from each of these summaries. Table 12 contains the results on the measures for each of the five baseline runs. In Table 13, the baseline results are compared to the actual combat runs made by the three selected participants.

Table 12 shows almost no tactical performance differences between the five baseline runs for the combat session. While the general and adaptive plans kept friendly attrition lower than the other plans, they allowed the most distance to be surrendered. The unaided plan inflicted the most enemy attrition but also suffered the most attrition to its own forces and gave up more territory. The modal and school solutions surrendered the least distance, but were about average on losses suffered and inflicted.

Table 13 shows that by adding participant interaction in combat, enemy attrition rates were increased. This was probably due to the effect of weapon expenditure. However, operator interaction had almost no effect on friendly force attrition or on the amount of distance surrendered.

To summarize, two major findings resulted from the baseline runs. First, the type of defensive operation plan used did not affect tactical performance

Table 12

Tactical Measure Summary: Five Baseline Runs Of Operations Plans By Update

Measure and Participant \ Update	4	8	12	16	20	24
Friendly Attrition (%)						
Modal	6.9	17.0	20.6	23.4	25.0	26.9
School	5.1	14.2	18.7	22.4	25.3	27.4
Unaided Participant	5.1	18.1	23.4	26.1	28.3	29.7
General Participant	9.5	24.1	27.1	20.0	21.4	22.4
Adaptive Participant	6.4	14.2	17.4	20.0	21.4	22.4
Enemy Attrition (%)						
Modal	0.7	3.4	6.3	8.7	10.8	12.8
School	1.0	3.8	6.7	9.0	11.2	13.1
Unaided Participant	0.7	3.3	6.6	9.5	11.9	14.4
General Participant	0.9	3.5	5.9	8.1	9.8	11.3
Adaptive Participant	0.6	3.3	6.1	8.5	10.4	12.1
Distance Surrendered (km)						
Modal	9.8	22.8	26.0	29.2	30.1	30.4
School	9.1	21.2	24.6	27.6	29.5	30.5
Unaided Participant	9.9	23.5	28.1	29.9	30.8	31.5
General Participant	7.9	20.3	26.3	29.7	31.0	31.5
Adaptive Participant	9.7	22.9	26.3	30.0	31.2	31.6

Table 13

Tactical Measure Summary: Baseline Run Versus Actual Run For an Operations Plan From Each Experiment Group By Update

Measure and Participant \ Update		4	8	12
Friendly Attrition (%)				
Actual	Unaided	5.0	19.0	24.0
Baseline	Unaided	5.1	18.1	23.4
Actual	General	10.0	23.0	27.0
Baseline	General	9.5	24.1	27.1
Actual	Adaptive	6.0	14.0	18.0
Baseline	Adaptive	6.4	14.2	17.4
Enemy Attrition (%)				
Actual	Unaided	3.0	8.0	16.0
Baseline	Unaided	0.7	3.3	6.6
Actual	General	4.0	8.0	13.0
Baseline	General	0.9	3.5	5.9
Actual	Adaptive	2.0	8.0	15.0
Baseline	Adaptive	0.6	3.3	6.1
Distance Surrendered (km)				
Actual	Unaided	9.9	23.0	27.3
Baseline	Unaided	9.9	23.5	28.1
Actual	General	7.9	20.3	26.6
Baseline	General	7.9	20.3	26.3
Actual	Adaptive	9.8	22.4	26.1
Baseline	Adaptive	9.7	22.9	26.3

in the simulated combat segment. Second, the functions performed by the participants during combat had little impact on most measures of tactical performance. The implications these findings have on the measurement of tactical performance in SIMTOS defensive combat are discussed in a later section of this report.

POST-EXPERIMENT QUESTIONNAIRE

Each participant completed a questionnaire immediately following their completion of the SIMTOS exercise. The questions comprising the instrument and a summary of the mean participant responses by group are given in Table 14. Participant background did not appear to influence the responses and the groups were homogeneous in their answers with the exception of Question 9. Seventy percent of the G-3 participants in the adaptive group felt they were not given sufficient time to learn how the system worked in planning, compared to 40 percent in the general and unaided groups.

In general, the participants agreed that computer systems would become part of, and influence the success of, tactical operations systems. The participants were satisfied with how the experimental session was handled (i.e., contact for participation, instructions, explanation of the tasks). However, they felt the system was difficult to learn to use.

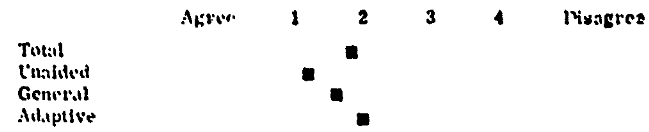
The questionnaire also contained a section for further comments. Comments received were generally favorable. The suggestion made by most participants was to lengthen the exercise time so the operators would not have to learn the mechanics of system operation while working the exercise itself. Comments from the unaided group indicated that some sort of decision support system is necessary in the design of future automated systems.

Table 14

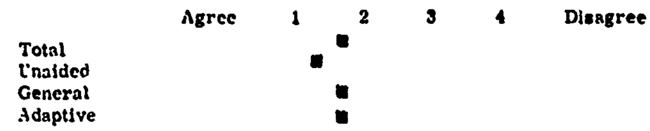
Summary of Post-Experiment Questionnaire Responses

N=26

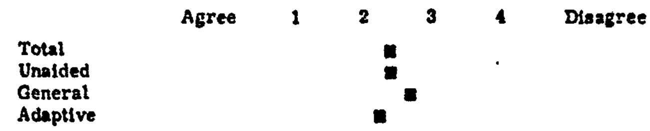
1. The use of computers in tactical operations centers is inevitable.



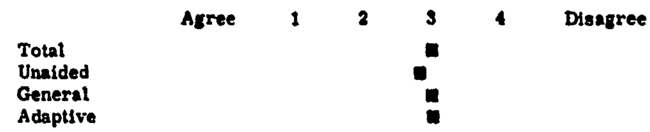
2. The appropriate use of computer systems in the division (TOC) will improve operating efficiency.



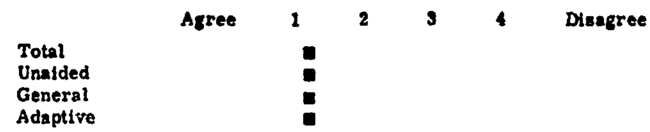
3. I had an easy time learning to use SIMTOS.



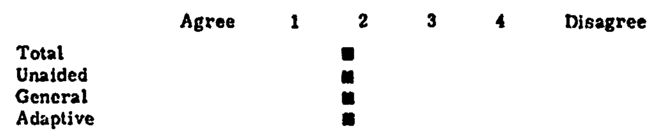
4. SIMTOS added to my ability to plan and conduct my assigned mission.



5. I was satisfied with the way I was contacted to participate in the SIMTOS activity.



6. In the future, the development of automated tactical information systems will have reached the point where they will significantly influence the success of tactical operations.



7. Were the instructions adequate in preparing you to play the scenario?

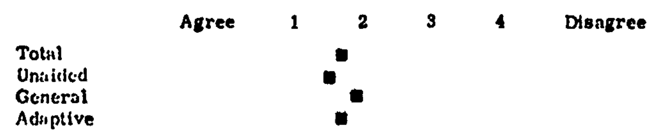


Table 14

Summary of Post-experiment Questionnaire Responses (Concluded)

N=25

8. Were they of sufficient detail?

	Yes	No
Total	72%	28%
Unaided	60%	40%
General	60%	40%
Adaptive	90%	10%

9. Do you feel you were given enough time in the planning session to understand the workings of the system?

	Yes	No
Total	48%	52%
Unaided	60%	40%
General	60%	40%
Adaptive	30%	70%

10. Did you spend time in the combat session learning to use the system?

	Yes	No
Total	88%	12%
Unaided	100%	0%
General	90%	10%
Adaptive	80%	20%

11. Do you feel you were given a satisfactory explanation as to what the aid was?

	Yes	No
Total	95%	5%
Unaided	--	--
General	90%	10%
Adaptive	100%	0%

DISCUSSION

OVERVIEW

The discussion is presented in three sections. In the first section, the evaluation of the decision support system in SIMTOS is treated. The second section discusses the implications of study findings for future research with the SIMTOS. The third section contains a discussion of the implications of SIMTOS research for automated Army tactical systems.

The objectives of the present study were to design, implement, and evaluate a decision support system for SIMTOS. In order to enhance SIMTOS human/computer dialog and to begin to make the SIMTOS more responsive to G-3 activities, the procedures followed during the play of the SIMTO defensive scenario were modified. The SIMTOS G-3 was given the opportunity to plan his defense interactively and then play this defense during combat. Decision support concepts were used to design specific aids from estimate of the situation and resource allocation aiding themes.[15] These aids were designed to be responsive to different aspects of the SIMTOS user's tasks and information processing activities. Results of the experiment demonstrated that the concept of decision support is sound. Due to the nature of tactical performance measures and some deficiencies remaining in the human/computer dialog however, the results are not definitive.

[15] The types of decision aiding are defined in Levit et al., Volume 1, 1974.

DECISION SUPPORT EVALUATION

Decision Style in Adaptive Aiding

The Decision Style Measurement Instrument (DSMI), while not validated in its present stage of development, did allow a differentiation of participants on decision style dimensions. The present study, as in the preliminary evaluation (Levit et al., 1974), found that the Active/Abstract/Intuitive (AAI) decision style was the modal style for a small sample of military participants. Fifty-six percent of the participants scored within the AAI style dimensions. The remaining participants were distributed across the other seven possible combinations of dimensions. These findings indicate that decision aiding procedures, responsive to individual preference in information processing, could be based on a modal decision style. The analysis of a greater sample of tactical officers however, is necessary before this conclusion can be finalized.

Planning Segment

A major focus of the present study was to test the feasibility of automating the G-3s planning activities in the SIMTOS environment and of providing decision support to aid the SIMTOS G-3s in these activities. G-3 operations plan development was categorized into discrete steps which were displayed on a CRT for on-line selection of tactical alternatives. A decision support system was designed which consisted of three forms of estimate of the situation aids: a time pacing aid, a data base information retrieval aid, and an order of completion aid.

The results indicate that on-line planning was an effective method for operations plan development. The step format with its choice of tactical alternatives eliminated the ambiguity of plan content. This facilitated the implementation of planning directives into defensive combat actions. Furthermore, on-line planning permitted individual variation within the general constraints of the planning exercise.

Observation indicates that on-line planning considerably enhanced the SIMTOS G-3s' activities. All participants in the present study completed their planning activities. In contrast, participants in the preliminary evaluation (Levit et al., 1974) where longer planning periods were provided, did not always complete their planning activities. On-line planning has thus emerged as a useful and productive adjunct for integrating G-3 activities with the SIMTOS.

The time pacing aid functioned in the hypothesized manner. A time standard was given for each of the planning steps along with the time available for completing the entire planning sequence. Generally, the SIMTOS participants followed the temporal guidelines provided. Time spent on the first step however, was confounded with system familiarization. Thus the participants usually spent more than the allocated time on the first step, but increased their completion efforts so that total completion time was within the temporal guidelines.

The data base information retrieval aid was designed to provide information from the data base relevant to each step of the on-line planning process. A TRANSFER option was provided to access this relevant information from the SIMTOS data base. The results show that this feature was generally not used. Only a small proportion of the total data base interactions were made via selection of the TRANSFER option.

Infrequent use of this option (only 12 of 20 aided participants used the transfer) was probably a function of the aids' failure to completely meet the criteria for successful decision aiding. The aid was not easy to use. The transfer appeared in a list which contained from six to nine other options. The process for selecting any option involved moving the cursor sequentially through the list, one option at a time, to the option desired (i.e., TRANSFER) and the another keyboard response to select that option. In addition, there was no explicit requirement for the participant use on the SIMTOS planning information data base. Thus, if the data base was perceived as nonrelevant to the task, an aid to getting the information from it would not be used.

Since all SIMTOS participants completed the steps of the on-line plan in sequential order, the effect of order of completion aid could not be assessed.

Therefore with the exception of completion time, decision support seems to have had little impact on the gathering, processing, and selection of information with respect to the on-line development of the operation plans. This may have contributed to the large variability in the resultant operations plans as exemplified by the analysis of planning information process discussed below.

The unaided group had significantly more data base interactions than the aided groups. The general aided participants also had significantly more data base interaction than the adaptive aided participants. These differences are reflected in the type of information queried. Results from the sources sought measure show that the intelligence and operations categories were queried more than the other categories. Elements of predicted enemy movement, strength, key terrain, and probable avenues of approach are contained in intelligence. Friendly force structure and strength are found in operations. These elements are the most crucial to the G-3 in planning his defense. All participants averaged about the same number of intelligence queries. However, while

the general and unaided participants made the same number of queries of the operations category as the intelligence category, the adaptive participants queried operations much less than intelligence.

Two factors might explain the observations previously discussed. First, querying the data base was the only available means the unaided participants hand of interacting with automated system during the planning segment. The on-line planning format, however, necessitated many types of interaction with the system by the aided participants. Given that there was no explicit requirement to use the data base, it could be expected that participants having only this function would use it more than participants having a number of interactive functions. Second, it could be hypothesized that because the information search was not directed, differences in the background of the participants in terms of prior experience influenced the amount and type of information needed to complete the planning task. Thus, there were differences in the amount and type of information sought from the SIMTOS data base due to experiment group task differences and hypothesized participant background differences (i.e., the participants may have used their own information sets to complete their operations plans).

Combat Segment

The combat segment of the present study was used to explore the tactical effectiveness of the operations plans developed during the planning segment and to evaluate decision support techniques during a simulated defensive combat situation. Each of the developed operations plans were implemented into combat directives sc the participants could play their own defense. Decision support for the combat segment consisted of unit status boards for the monitoring functions and resource allocation for implementation of

directives. The status boards provided a range of information for monitoring the current status of friendly and enemy force units. The resource allocation aid provided an efficient method of summarizing available fire support elements and directing specific weapon firing. The results, discussed below, indicate that these concepts are sound, but in the present study still suffered in terms of effective human/computer dialog related to the SIMTOS combat scenario tasks.

The status boards were available to the aided participants. The general aided group had units pre-established on their status boards (these could be modified before the combat segment began), while the adaptive aided group selected their own units for monitoring. The unaided group had only the SRI function for monitoring purposes. The reported differences in the use of the functions thus reflected inherent group task differences. However, the establishment function (comparing establishment of SRIs by the unaided group to establishment of both status board information and SRIs by the aided groups) occupies a larger portion of the unaided group's total time across the problem that of the aided groups. This suggests that the SRI mechanism was less than efficient in meeting the needs of the unaided participants. The unaided participants may also have required a different presentation format than was provided by the system.

In a battlefield situation, the G-3s main task is to monitor the course of the battle relative to his operations plan. Depending upon observed fluctuations from this plan, the G-3 would make recommendations concerning the priority of weapon fires, force organization, mission assignment, counterattack, reserve commitment, etc. The emphasis of these recommendations would be general directives for what should be done rather than the specifics of implementation.

In the combat segment of the SIMTOS defensive scenario, the G-3 participants could monitor the course of the battle via the status boards and/or SRIs. It was hypothesized that status boards, by increasing the amount of information readily accessible, would enhance the monitoring function and thus positively affect tactical performance. However, instead of making general recommendations for a course of action, the SIMTOS task required the participants to attempt to change the course of the battle through implementation of specific directives. The implementation functions involving weapon fires and battalion unit location charges (discussed later) were the same for both the aided and unaided participants. Therefore, due to the discrepancy between the G-3s' task as operationally defined and as required for SIMTOS, much of the impact of the status boards was lost due to the specificity of the information needed to implement SIMTOS combat directives.

The use of the resource allocation by the aided participants remained constant through combat. The unaided group, on the other hand, discontinued their use of this function toward the end of the combat segment. Use of the unit move function increased for all participants, but more so for the unaided group as combat progressed. This suggests that the initial focus of the participants was on firing weapons. As the enemy forces continued to advance however, the participants attempted to use the technique of unit movement rather than weapon response as a means to slow the advance.

In summary, there were many differences in the defensive directives implemented from the participant operations plans into the combat segment. Also, the participants were homogeneous in their use of the system functions available in the combat segment. Yet, no differences were observed among participants on combat tactical performance measures. To examine this

apparent discrepancy, five different defensive operation plans were used for baseline or non-operator interaction combat runs. The plans, described in the results section, were a modal plan, a school solution, and one participant plan from each experiment group.

The tactical performance measures of friendly force attrition, enemy force attrition, and distance surrendered were derived from each of the baseline runs. There was no difference between the plans on any of these measures across a simulated 12-hour combat session. Furthermore, when the experimental group baseline runs were compared to actual participant interaction runs, the outcomes were very similar. There was slightly more enemy attrition in the actual runs, which was probably due to the use of artillery and air strikes. However, this did not affect own force attrition or the amount of distance surrendered.

Thus, it can be concluded that participant interaction in combat had little or no effect on the tactical outcome. These results indicate that the scenario outcome is not sensitive to any functions performed by the participant or to differences in the defensive planning.

IMPLICATIONS FOR RESEARCH IN SIMTOS

From the present and the preliminary investigations of decision aiding in SIMTOS (Levit et al., 1974), a rich data base on human/computer interaction with the system has been generated. While these data, particularly from the planning phase, were explored, the emphasis has been with the effect of decision aiding on measures of tactical performance. While questions concerning the effect of decision aiding on tactical effectiveness are important and relevant to SIMTOS studies, the results showed that the analysis of

terminal performance measures do not reflect the richness and variability of the SIMTOS user's decision making behavior. In fact, the results indicated that the terminal measures of performance used in the present analysis (friendly and enemy force attrition, friendly force artillery expenditure, friendly force air strikes, distance surrendered), were relatively insensitive to G-3 decision making behavior. These findings imply that the terminal performance measures used are not adequate for the evaluation of decision aiding concepts and that differences in tactical performance as measured by these indices cannot reveal much about the nature of G-3 decision making or user/system interaction.

However, another set of findings indicates that much useful data is available for the study of SIMTOS G-3 decision making behavior. This data is not available from terminal performance measures, but from a protocol-type analysis of G-3 activities from the SIMTOS track file.

In the present and past investigation, an attempt was made to develop and study intermediate measures of information processing. This lead to the analysis of system interaction functions, sources sought, time, redundancy, usage efficiency, etc. This methodology was not sufficiently advanced to characterize decision making and user/system interaction in the SIMTOS environment. However, it allowed qualitative generalizations to be made concerning the nature of information processing in SIMTOS and the relationship between these processes and G-3 information requirements, decision making and user/system interaction. These findings demonstrate that a protocol type analysis could be used to develop a coherent picture of how the G-3 uses SIMTOS in his activities.

While examination of SIMTOS protocols could provide much guidance on techniques for increasing system sensitivity, another important source of information is the tactical doctrine associated with the performance of the G-3 role in the division tactical operations center (TOC). Tactical doctrine can provide the outer boundaries for G-3 decision making. It can direct the course of G-3 activities as well as emphasize certain information requirements and analysis products. In the present study, an examination of this doctrine enabled the G-3 planning tasks to be formated to allow on-line completion of the operations plan. Therefore, the study of G-3 tactical doctrine is an important source of information on tactical decision making.

The focus of future research in SIMTOS should thus combine the knowledge gained through a protocol analysis with the knowledge of G-3 tactical doctrine. A set of requirements could thus be developed for G-3 interaction in a Simulated Tactical Operations System. Such a set of requirements would stipulate the information requirements, retrieval options, human/computer dialog procedures and data base structure necessary for G-3 operations in an automated environment. This set of requirements would be the foundation for the extension of decision support concepts in SIMTOS.

IMPLICATIONS FOR AUTOMATED TACTICAL SYSTEMS

The principle of decision support states that to maximize the effectiveness of the human/computer decision making dyad, a variety of decision aids (a complex) should be integrated into automated tactical systems. The type and nature of the decision aids which might compose such a decision support complex are many and the effect of such aids on decision making behavior and tactical performance is still uncertain (Levit et al., 1974; Nickerson and

Feehrer, 1975). The present investigation represented an effort to study and implement a decision aiding methodology in a Simulated Tactical Operations System. The investigation emphasized the quantitative evaluation of two types of decision aids on measures of information processing and tactical performance. The analysis of information processing measures indicates that decision aiding procedures do affect the behavior of system users, particularly during the planning segment of the SIMTOS defensive scenario. Decision aids which make available the appropriate information, tailored to the information processing characteristics of the user, can play an important role in tactical planning. This finding is fortunate since many authorities indicate that planning is the most important component of the tactical command and control process (Payne, Miller and Rowney, 1974). The effect of decision aiding on tactical performance however, is still equivocal. The complexity of the tactical environment as well as the small effect sizes associated with decision aiding diffuse the possible statistical effects of decision aiding on tactical performance. At the present time, this lack of effect on tactical performance is confounded by the nonresponsiveness of the combat scenario to operator inputs. The analysis of the baseline SIMTOS runs presented in the results section indicates that the scenario must be made more responsive to operator inputs if decision aiding techniques are to receive a fair evaluation using tactical performance measures.

The purpose of the SIMTOS decision aiding studies is to build an empirical data base from which the designers of future automated tactical systems can draw. These efforts are extremely important since Army command and control is still a manual and interpersonal procedure, and has been judged inadequate when compared to the capabilities of available technology (Albright, 1975). Even where partially automated systems have been available, such as

in the National Military Command Center (NMCC), the problems of human/computer dialog have yielded considerable user dissatisfaction. Information retrieval results in such voluminous outputs that it is extremely difficult to find the specific data needed. Data processing support does not permit on-line data base update nor the maximization of information query performance. As a result, the summarization of tactical data meaningful to the decision making process continues to be a manual process. This state of affairs cannot be allowed to continue. The complexity of the modern tactical environment (as recently demonstrated in the Yom Kippur War and the Cyprus crises) necessitates the near-term development of information systems which support the tactical decision making function. The SIMTOS decision aiding studies have been responsive to this Army requirement. They have contributed specific data on decision aiding methodologies as well as provided a series of general guidelines for the development of automated tactical information systems. Some of these guidelines are discussed in the remainder of this section.

A simplified but valid definition of an automated tactical operations system is one which provides the right information in the right format at the right time. The system must provide for the judicious sorting, selection and presentation of information from a wide variety of sources in a timely, accurate and concise manner. It must effectively interface the decision maker with the information he needs in the format most useful to him. Thus, the key to competent decision making is the availability of current and accurate information. It is not the quantity of information which is important. Rather, it is the process of selecting the pertinent information, assessing its significance, and displaying it in a readily understood format which facilitates the decision making process (Albright, 1975). Furthermore, quantity of available information should not be mistaken for sufficiency.

The effective automated system should complement the action officer's ability to select salient information from the large amount of data available to him. Therefore, information should be presented on the basis of what is required rather than what is available. Furthermore, it should be presented in a manner that is meaningful to the system user. The adaptive estimate of the situation decision aid investigated in this study is responsive to this requirement.

The provided planning information was selected for relevance and responsiveness to the information processing needs of the decision maker. Furthermore, the information was presented on-line in a level of detail such that the content could be rapidly understood and utilized. In combat, this on-line capability gave the SIMTOS user the ability to retrieve historical data and display it in a format meaningful for use with current operations and intelligence data. Thus, the consideration of techniques for information selection and presentation as decision aids is probably one of the most important generalizations or guidelines emerging from the present study.

Another important characteristic of automated tactical systems should be the capability for rapid identification of resources. Such identification should emphasize both availability and the capability for satisfying certain tactical requirements. The resource allocation aiding procedure used in this study satisfied this requirement. During the combat segment, the resource allocation procedure identified the tactical resources available to strike a specified target. The aid also contained an option which allowed the user to easily order the desired response using on-line interaction. The necessity for such an aid in an automated system was illustrated by the fact that SIMTOS participants could not successfully complete the exercise without it.

Decision aids such as the ones discussed previously cannot be added haphazardly to a tactical system. First of all, the aids themselves should satisfy a number of criteria. These criteria have been discussed in the introduction to this report. Second, the aids must be integrated into the system in a manner which is cognizant of the ways such aids will be used. Meaningful techniques of human/computer dialog are thus essential to any decision aiding methodology (Levit et al., 1974). Such dialog techniques should result in the operational user using the system precisely, rapidly, and in a manner which satisfies his needs. The system which does not perform in such a manner will be abandoned for more familiar manual methods.

The process of developing automated Army tactical operations systems is only beginning. The concept of decision support and human/computer dialog are important contributions to the realization of such systems. System designers however, should be aware of two caveats (or warnings) when speculating on the nature of such systems. One caveat regards the one systems philosophy. The entire automated system including computers, storage devices, displays and communications interfaces, and software should be integrated so that it responds as one system. Thus, system designers must understand the system's mission and usage from the same point of view as the decision makers who will be using the system. The second caveat is that the impact of user acceptance should not be underestimated. Some decision makers will quickly adapt to and thrive in an automated environment; others will find it difficult to modify their personal decision making techniques and will attempt to circumvent the system with degraded results. The use of adaptive decision aiding (procedures responsive to decision style) as well as thorough training programs should do much to cushion the impact of such systems on the latter group. For if automated

tactical systems are to be successful, the decision makers whom they serve must be thoroughly familiar and confident in the system and its capabilities (Albright, 1975).

REFERENCES

1. Albright, A.F., Processing and display of information in the national military command center (NMCC). U.S. Army War College, Carlisle Barracks; Pennsylvania, 23 May 1975.

2. Bunker-Ramo Corporation, G-3 offensive and defensive scenarios-simulated tactical operation system (SIMTOS), Final Report. Submitted to: U.S. Army Behavior and Systems Research Laboratory, April 1973.

3. Department of the Army Field Manual, Staff officer field manual staff organization and procedure. FM No. 101-5, Headquarters, Department of the Army, Washington, D.C., 19 July 1972.

4. Department of the Army Field Manual, The infantry battalions. FM No. 7-20, Headquarters, Department of the Army, Washington, D.C., 8 December 1969.

5. Levit, R.A., Alden, D.G., Erickson, J.N., and Heaton, B.J., Development and application of a decision aid for tactical control of battlefield operations: Volume 1: A Conceptual structure for decision support in tactical operations systems; Volume 2: Decision style measurement and decision support software specifications; Volume 3: A preliminary evaluation of a decision support complex in SIMTOS. Honeywell Technical Report, August 1974.

6. Nickerson, R.S., and Feehrer, C.E., Decision making and training: A review of theoretical and empirical studies of decision making and their implications for the training of decision makers. Bolt, Beranek, and Newman, Inc., Technical Report: NAVTRAEQUIPCEN 73-C-0128-1, August 1975.

7. Payne, J.R., Miller, A.C., and Rowney, J.V., The Naval task force decision environment. Stanford Research Institute, Menlo Park, California 94025, Technical Report NWRC-TR-8, 1975.

8. Winer, B.J., Statistical principles in experimental design. McGraw-Hill Book Company, 1962.